Special Article

Factors Affecting the U.S. Farm Price of Upland Cotton

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Abstract: An annual model that explains the U.S. upland cotton farm price includes various market components, as well as government loan and storage programs in selected years. With the declining role of government agricultural programs, however, market supply and demand conditions, both in the United States and around the world, are now more influential in determining U.S. cotton prices. An overall measure of supply and demand is provided by the stocks-to-use ratio, which is a useful tool in explaining inter-year price movements. The regression model presented explains 92 percent of the variation in upland cotton prices during the 1978 to 1996 marketing years. In addition, the effect of shifting one variable at a time and its impact on upland farm prices is highlighted for each explanatory variable.

Keywords: Upland cotton, farm price, price determination, ending stocks, stocks-to-use ratio.

Cotton is one of the world's most important textile fibers, accounting for about 45 percent of fiber production. In 1997/98, U.S. farmers produced over 20 percent of the world's cotton, while U.S. mills used 13 percent of the world total or 20 pounds for each person in the country. And, because cotton is a major raw material for the textile and apparel industries, cotton production, marketing, and manufacturing affect the lives of many people from producers to consumers. Cotton is a vast and dynamic industry that accounts for more than $25 billion in products and services annually in the United States.

Many interrelated factors help determine the price of U.S. cotton, such as the fundamental elements of supply and demand and the effects of agricultural policy. These factors have various implications for the cotton industry, as well as many other industries, that extend well beyond the farm gate.

Background

Recent agricultural legislation has altered the nature of U.S. Government commodity programs, advancing the efforts toward increased market orientation. In particular, the 1996 Farm Act decoupled the income support programs that were in place for many years, and shifted the price volatility risk from the government to producers (see Young and Westcott). As a result, market information has become increasingly essential as producers and other market participants seek to make informed pricing decisions under a more market-oriented agricultural environment.

The U.S. Department of Agriculture (USDA) analyzes and publishes monthly supply and demand data and information pertaining to the major agricultural commodities. In addition, USDA publishes forecasts of season-average farm prices for these commodities. Cotton is the exception, however, as USDA is prohibited by law from publishing cotton price forecasts (see Townsend, 1989). Nonetheless, USDA calculates unpublished cotton price estimates for internal Departmental use each month along with the other reported U.S. and foreign cotton supply and demand estimates. Additionally, USDA analysts examine reasons explaining historical movements in commodity prices, including cotton prices.

This paper analyzes some of the factors that have historically influenced U.S. farm level cotton prices. An annual upland cotton price model is developed and designed to be used by USDA with other price estimation techniques in the analysis of market forces affecting the supply and demand for cotton. For an annually produced crop like cotton, ending stocks for a particular year summarize these supply and demand forces and can be a useful indicator of price movements. Annual cotton prices tend to be negatively correlated with ending stocks; high stocks of cotton tend to depress prices while low stocks tend to support prices, all other things being equal.

Agricultural policies and programs, such as the nonrecourse loan program, have also influenced prices, although the

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results of these programs have differed under the various farm policy environments. The basic loan program allows producers to obtain loans for a commodity, in exchange for placing that commodity as collateral in approved government storage. At the producer's option, the loan, including any accrued interest and/or storage charges, can be repaid at any time during the loan period, or the commodity can be forfeited to the government at the end of the loan period if market prices are not high enough to make economic sense for the producer to repay the loan. For upland cotton, significant forfeitures occurred in the early 1980's.

However, with the passage of the 1985 farm legislation, a new program, the marketing loan, provided a repayment option below the loan rate for upland cotton when the U.S. price was not competitive on the world market. The 1985 Act allowed upland cotton producers to repay loans at the lower of the loan rate or the adjusted world price (AWP). The marketing loan remains in effect under the 1996 Act and has eliminated the large forfeitures seen in the past.

Previous research addressing factors affecting commodity prices has included the stocks-to-use ratio. This ratio is defined as the stock level of a given commodity at the end of a particular period divided by the total use of that commodity for that same period. Thus, the stocks-to-use ratio provides a good summary of the year's supply and demand situation and is comparable over time. Similar to other research, the stocks-to-use approach was employed as the basis for this price determination analysis.

There is no single price for cotton, as numerous daily, monthly, and annual price series reflect different markets, qualities, and/or delivery times. Nevertheless, each series is linked by the fundamental elements of supply and demand. This paper presents efforts by the Economic Research Service to reevaluate factors affecting farm price movements for major commodities under the more market-oriented agricultural environment. While the annual estimate of the average U.S. upland cotton farm price, in and of itself, may be less useful to those who must follow monthly or daily prices, the factors that influence the annual price provide a framework that allows a better understanding of intra-year price movements and perhaps a more informed decision about cotton price movements in general.

Model Specification

The model specification presented here follows a general equilibrium model with a basic framework relating prices to ending stocks. In its simplest form, which excludes government price support programs, stocks are a function of price; and, in equilibrium, prices are inversely related to stocks (Westcott). This basic model is used, to which adjustments are introduced that shift the price relationship.

The following functional form was used in estimating annual upland cotton farm prices:

$$\text{Ln (PRICE)} = a + b\ \text{Ln (S/U)} + c\ \text{CHFSTKS} + d\ \text{INDEX} + e\ \text{DSU} + f\ \text{Ln (LDP)*D1} + g\ \text{Ln (1+CCC/USE)}$$

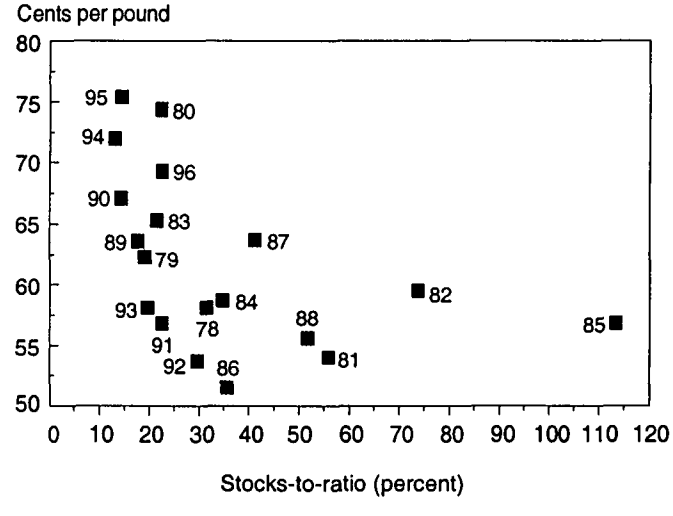
where the dependent variable is the natural log of the marketing year average price received by upland cotton producers. This price is a weighted annual price based on marketings throughout the year and is reported in cents per pound.

The price model's independent variables hypothesized to affect prices account for both U.S. and foreign market supply and demand conditions and U.S. agricultural policy programs, which have altered the supply and demand of cotton in the past.

The basic model relates stocks-to-use ratios to prices. The S/U variable is the upland stocks-to-use ratio for a given year, and is reported as a percentage. This variable indicates the tightness of U.S. supplies relative to demand. Figure A-1 shows a historical plot of U.S. farm prices for upland cotton and stocks-to-use ratios for the 1978 through 1996 marketing years. As the stocks-to-use ratio changes, the effect on prices is expected to be in the opposite direction. The variable is included in the model in logarithmic terms.

Other supply and demand conditions affecting price are introduced with the next three variables. The CHFSTKS variable is the percentage change for a given marketing year, from the previous year, of total foreign ending stocks, excluding China's. This variable is representative of the foreign cotton supply and demand situation outside of China. As this variable changes, the effect on prices is expected to be in the opposite direction. For example, if the percentage change in foreign stocks (less China) declines from the pre-

Figure A-1
Upland cotton prices and stocks-to-use ratios, 1978-1996 marketing years



vious season, this indicates that global cotton demand exceeded global supplies, so U.S. farm prices are expected to increase, all other things being equal.

Stocks in China are excluded from this variable partly because there has been much debate in the cotton industry over the size of China's stocks. Market analysis of the foreign situation and outlook often omit China, as policy actions there pertaining to cotton do not always reflect responses to market supply and demand conditions, particularly related to stocks. However, because China is the largest producer and consumer of cotton, changes in China are often reflected in the supply and demand balance sheets of other countries, including the United States. Therefore, omission of China stocks is not expected to reduce the overall effectiveness of the specified price model.

The INDEX variable weights the percentage of cotton crop acreage forward contracted by the end of September of a given year multiplied by the September average of the December futures contract of the same year. The index is inversely related to early season supply expectations. For example, if supply expectations are low, December futures tend to be higher and therefore more acreage tends to be forward contracted. And, because the farm price is based on marketings (including forward contract deliveries), the larger the percentage of acreage forward contracted, the greater role the index plays in determining the marketing year average price. Thus, the index is positively related to price.

The DSU variable represents the effects of starting a new marketing year with very tight beginning stocks. DSU is a dummy variable equal to one in years when the stocks-to-use ratio of the previous year is less than or equal to 22.5 percent and zero in all other years. During the sample period, the stocks-to-use ratio was less than or equal to 22.5 percent in 1979-1980, 1983, 1989-1991, and 1993-1996. Therefore, DSU is equal to one in the marketing year following each of these years. When the stocks-to-use ratio of a given year is less than or equal to 22.5 percent, the subsequent marketing year's prices may be high and total use may be limited, particularly in the early months before the new crop is harvested and becomes available. This variable is an intercept shifter and is expected to have a positive sign.

The next two variables are program variables related to current or past agricultural policy. The LDP variable is the loan deficiency payment rate for upland cotton, equal to the loan rate less the effective loan repayment rate. This program was first implemented for the 1986 marketing year as established in the 1985 Act. Since implementation, loan deficiency payments have been issued in only 4 years (1986 and 1991-1993) during the sample period and ranged from 6.35 to 11 cents per pound. Natural logs of this variable are used in the model. The transformed loan deficiency payment rate is multiplied by D1, a dummy variable equal to one during years when the loan repayment rate was below the loan rate and zeroes in all other years. Since loan deficiency payments are not included in the reported average price received by producers, the addition of this payment to the reported price would reflect a "more accurate" effective price received. Therefore, when loan deficiency payments are made, market prices tend to be lower, so there is a negative correlation to the price received by producers. This variable is an intercept shifter for the years when loan deficiency payments are made.

The final variable is CCC/USE, which is the Commodity Credit Corporation (CCC) stocks divided by total use for a given year and expressed as a percent. Natural logs of one plus CCC/USE are used in the model, keeping the transformed variable from falling below zero. This program variable becomes relevant when CCC inventories are large, as during the 1982 through 1985 crop years when the loan program for upland cotton was influential in forfeitures to the CCC. Between 1982 and 1985, CCC inventories of upland cotton, ranging from 124,000 to 775,000 bales, were substantially larger than at any other time during the data period analyzed. The transformed variable is positively related to price and is an intercept shifter for years when CCC inventories of upland cotton are held.

Results

The upland farm price model was estimated using ordinary least squares regression, using annual data for marketing years 1978 through 1996. The estimated regression equation is:

$$\begin{aligned}\text{Ln (PRICE)} = {} & 4.32596 - \underset{(-4.71)}{0.09740}\ \text{Ln (S/U)} - \underset{(-3.90)}{0.00276}\ \text{CHFSTKS} \\ & + \underset{(5.17)}{0.00559}\ \text{INDEX} + \underset{(3.24)}{0.06293}\ \text{DSU} - \underset{(-4.27)}{0.04377}\ \text{Ln (LDP)*D1} \\ & + \underset{(3.97)}{0.07212}\ \text{Ln (1+CCC/USE)}\end{aligned}$$

Adjusted R-squared = 0.9247
F-statistic = 37.84
Standard error of the estimate = 0.03102
Durbin-Watson statistic = 1.794
Degrees of freedom = 12

Over 92 percent of the variation in (the log of) annual upland cotton prices is explained by the equation. The numbers in parentheses below each coefficient are the t-statistics. Each coefficient has the expected sign and each is significant at the 1-percent level.

Model Performance

Figure A-2 shows historical upland cotton farm prices and the associated predicted values derived from the estimated

equation. As illustrated, the price model tracks actual cotton prices well. Most differences between the actual upland farm price and the model estimate are less than 2 cents per pound. The largest difference (3.2 cents) occurred in 1996, a recent year where revisions to foreign supply, demand, and stock data are still possible.

In addition, mean absolute errors and mean absolute percentage errors were calculated for the full estimation period, and for selected subsamples of recent marketing years. Throughout the entire estimation period, the mean absolute error was 1.3 cents per pound, while the mean absolute percentage error was 2.1 percent. During one subsample period covering the 1991-1996 marketing years, the errors are slightly higher due to the difference in 1996. For the 1991-1996 period, the mean absolute error was 1.5 cents per pound, while the mean absolute percentage error was 2.3 percent. However, if 1996 is excluded from the subsample, the mean absolute error declines to 1.1 cents per pound and the mean absolute percentage error decreases to 1.8 percent. These statistical measures indicate good performance of the upland cotton pricing model.

Model Features

Upland stocks-to-use ratios have been below 30 percent since 1988, although they ranged from 13 to 113 percent during the estimation period. While stocks-to-use ratios for upland cotton are expected to remain below the 30-percent level under the current policy environment, the various features of the regression equation results are illustrated using stocks-to-use ratios ranging from 5 to 100 percent.

A base model relationship was first determined by varying stocks-to-use while holding the CHFSTKS and INDEX variables at their sample means, DSU equal to one, and zeroes for the other variables (see table A-1). The base model results (solid-line curve) and the different features of the regression model are illustrated in figures A-3 through A-7. For each graph, upland cotton prices are plotted against ending stocks-to-use ratios, adjusting the variables from logarithms to levels. The base model curve is identical in each figure. Therefore, each graph illustrates the effect of shifting one explanatory variable at a time from the base model values, highlighting that variable's influence on prices.

Table A-1--Upland cotton price model assumptions used in model feature illustrations

Variable	Base model values	Shift values
S/U	5 - 100%	5 - 100%
CHFSTKS	0.82%	13.57% and -11.94%
INDEX	15.53	26.07 and 4.99
DSU	1	0
LDP	0	8.8 cents
CCC/USE	0	2.90%

Note: Base model values for CHFSTKS and INDEX equal sample means, while shift values equal the mean plus and minus one standard deviation. Base model value for DSU corresponds to beginning stocks-to-use of less than or equal to 22.5 percent, representative of the current situation. Shift value for LDP corresponds to the 1986 and 1991-1993 mean logarithmic value. Shift value for CCC/USE corresponds to the 1982-1985 mean logarithmic value of the transformed variable (1+CCC/USE).

The base model equation and the effects of the previous year's stocks-to-use ratio on cotton prices are shown in figure A-3. The higher (base model) price curve incorporates the effect of upland stocks-to-use ratios in the previous year of less than or equal to 22.5 percent (DSU=1). The lower dotted-line price curve represents the price effect of upland

Figure A-2
Upland cotton prices--Actual and model estimate

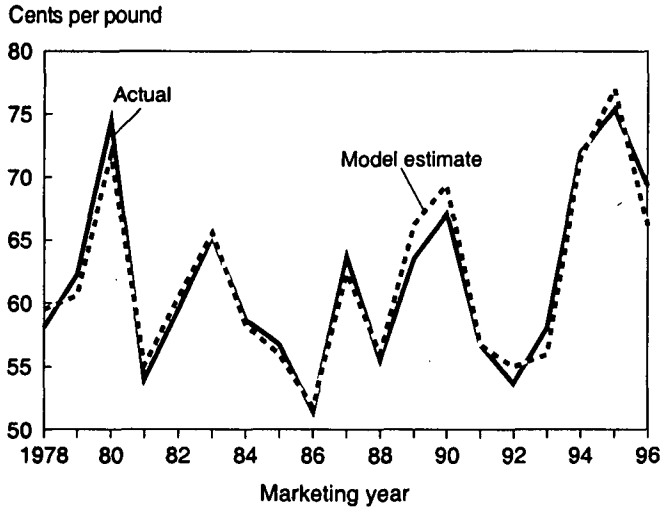
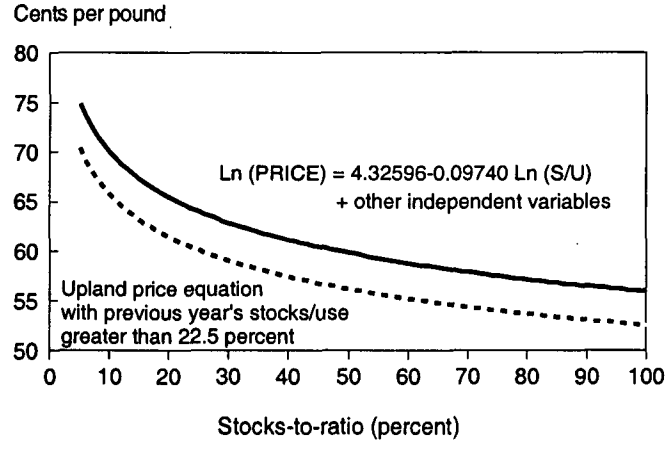


Figure A-3
Upland price equation--Previous year's stocks/use effect



For each curve, other independent variables evaluated at their base model values (see table A-1).

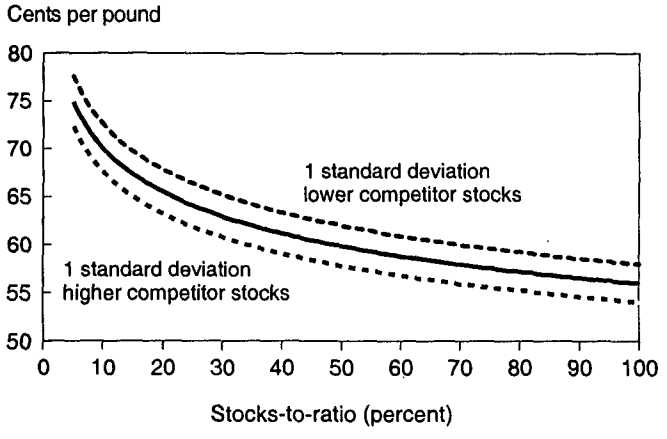
stocks-to-use ratios in the previous year of greater than 22.5 percent (DSU=0), holding all other independent variables at their base model values. Price impacts shown in figure A-3 range from -3.4 to -4.5 cents per pound when the previous year's stocks-to-use ratio is greater than 22.5 percent when compared with the base model.

Figure A-4 illustrates the effects on cotton prices for different percentage changes in foreign stocks less stocks in China. The base model is again represented by the solid-line curve, while the two dotted-line curves represent one standard deviation above and below the sample mean of the variable, CHFSTKS. This deviation corresponds to a 13.6-percentage-point increase in foreign stocks (less China) and an 11.9-percentage-point decrease. Compared with the base model, price impacts illustrated here are -2 to -2.6 cents per pound with the increase in competitor stocks and 2 to 2.7 cents per pound with the decrease in competitor stocks.

Figure A-5 indicates the sensitivity of the upland cotton price function for different INDEX values related to the amount of the crop that was forward contracted and the level of the December futures contract. The base model along with the two dotted-line curves, representing one standard deviation above and below the sample mean, are pictured. One standard deviation above the mean corresponds to an index of 26.1, while one standard deviation below corresponds to an index of 5.0. Price impacts shown here range from 3.4 to 4.6 cents per pound with the higher index and -3.2 to -4.2 cents per pound with the lower index when compared with the base model.

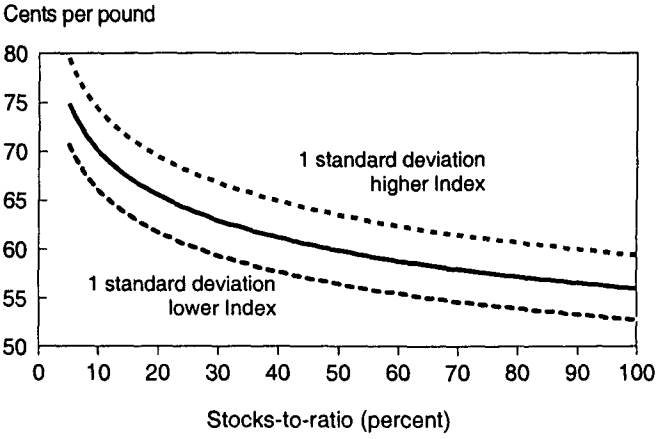
As indicated from the results in figures A-4 and A-5, one standard deviation around the INDEX variable causes a greater impact on prices than one standard deviation around

Figure A-4
Upland price equation--Foreign stocks less China effect



For each curve, other independent variables evaluated at their base model values (see table A-1).

Figure A-5
Upland price equation--Forward contract index effect



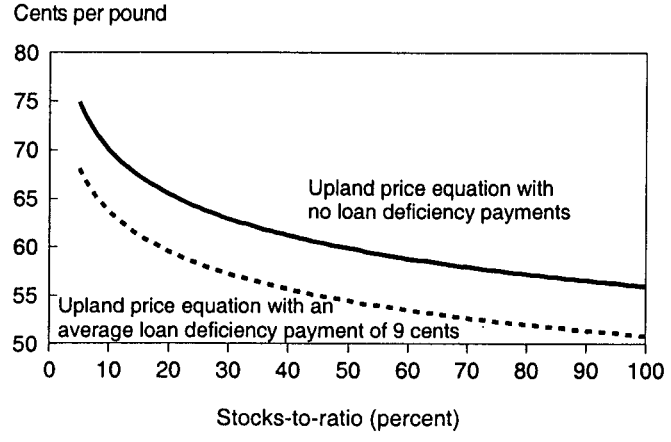
For each curve, other independent variables evaluated at their base model values (see table A-1).

the CHFSTKS variable. However, the INDEX variable would be finalized early in the marketing year (early October), while the competitor stocks variable would be expected to change throughout the season as better information and data became available. Therefore, the effect on prices for the CHFSTKS variable may shift several times throughout the season.

The effect of loan deficiency payments on upland cotton prices is shown in figure A-6. The upper curve represents the base model when no loan deficiency payments are made. The lower dotted-line curve, on the other hand, illustrates the price effect of loan deficiency payments averaging about 9 cents per pound, corresponding to the mean logarithmic value of these payments for the 1986 and 1991-1993 marketing years. As discussed earlier, these payments are not included in the reported farm price for upland cotton. Therefore, the payment value should be added to the reported price to get a "more representative" indicator of the effective price received by producers in years when loan deficiency payments are made. Price impacts shown in figure A-6 range from -5.1 to -6.8 cents per pound, compared with the base model, corresponding to average loan deficiency payments of about 9 cents.

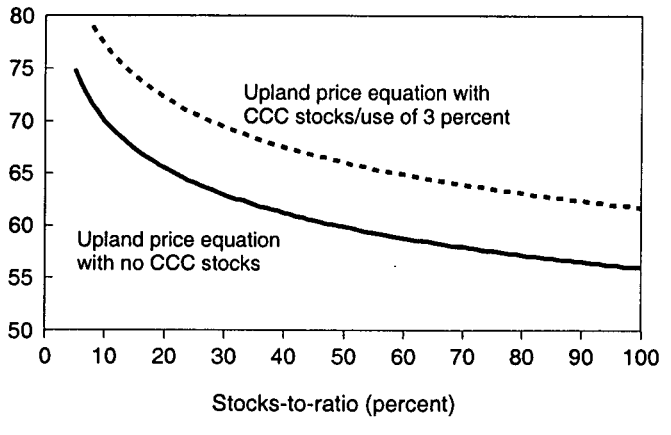
Figure A-7 illustrates the effect of CCC stocks on cotton prices. The solid-line curve represents the base model when there are no inventories of CCC stocks. The upper curve indicates the price supporting effect of having stocks unavailable to the marketplace and held as CCC inventory. The dotted-line curve represents a CCC stocks/use ratio of about 3 percent, corresponding to the mean logarithmic value of the 1982-1985 marketing years, the period when CCC inventories of cotton were much higher than at any other time during the estimation period. Price impacts illustrated on the graph range from 5.7 to 7.8 cents per pound

Figure A-6
Upland price equation--Loan deficiency payment effect



For each curve, other independent variables evaluated at their base model values (see table A-1).

Figure A-7
Upland price equation--CCC stocks/use effect



For each curve, other independent variables evaluated at their base model values (see table A-1).

when average CCC stocks/use ratios of about 3 percent are present when compared with no CCC stocks.

Out of Sample Estimate

The largest error in the model, as discussed earlier, occurred in the last year of the estimation period, 1996. So, there was a concern about the model's performance in future years. Did the 1996 farm legislation provide additional factors, not accounted for in this model, that were more influential in determining farm prices or was 1996 just an outlier? While USDA, by law, cannot forecast cotton prices, the first out-of-sample estimate for this model was the 1997 marketing year that ended in July 1998. Model variables, therefore, are not expected to change significantly and the average upland price received by farmers has been reported by USDA for the 1997 season.

The price model presented here was used to estimate a farm price for upland cotton using the latest available data (November 1998) for the 1997 marketing year. The model estimated the 1997 marketing year average price for upland cotton to be 63.2 cents per pound, while the actual farm price, reported by USDA, was 65.2 cents per pound. Although the regression equation underestimated the price by 2 cents per pound, the first out-of-sample estimate is within one standard error of the model estimate. And with limited data, it is difficult to determine whether the 1996 farm legislation has introduced "new" factors that influence farm prices that are not already captured by the model estimated here. Perhaps additional research into the model's underestimation of upland farm prices in 1996 and 1997 may be useful for future work.

Conclusions

The upland cotton price determination model presented in this article uses a stocks-to-use ratio framework. In addition, the model addresses issues regarding the historical influence of government commodity loan and storage programs on cotton prices. These programs were shown to have affected upland cotton price determination during the early 1980's, prior to the passage of the 1985 farm legislation. With the implementation of the 1985 Act, however, storage programs have not influenced upland cotton prices significantly, but the cotton loan program remains an important component. As U.S. prices are more closely tied to world market conditions, foreign market supply and demand expectations, as well as U.S. conditions, have played a larger role recently in affecting the price received by U.S. upland cotton producers. The stocks-to-use ratio and other variables identified in the model have shown the importance of market supply and demand factors on upland cotton price determination.

The statistical model's evaluation measures and the graph illustrating the actual prices and model estimates indicate the effectiveness of the regression model in the determination of upland cotton prices. This is particularly relevant given the wide range in upland cotton prices over the sample period (1978-1996), as well as the changes in agricultural policy that have had varying impacts on prices.

Carryover stocks of upland cotton as a percent of total use are typically smaller in the 1990's than in any previous period. Therefore, price determination is in the steeper portion of the price function and implies more price responsiveness to shocks. However, with the continued full planting flexibility currently in place, market signals and producers' responses to these signals may help mitigate the large annual variability in upland cotton prices seen in the past.

Finally, the relatively simple structure and the limited data needs of the regression model presented in this article allow for sensitivity analysis under various market supply and demand conditions that may develop during a given year or from one year to the next. While USDA does not publish cotton price forecasts, this model, along with other models, is used to analyze historical cotton price movements and is used in USDA's short-term market analysis as well as long-term baseline projections.

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